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Selection Strategy in Local Upland Rice Germplasm Collection of Odisha

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Abstract A set of ninety six land races including popular upland varieties were assessed for genotypic worth as compared to standard check variety Vandana. Drought tolerance parameters (LRS, DRS and LDS), zinc tolerance, BLB tolerance, panicle weight and grains per panicle had shown higher degree of genetic variability (CV ≥40%). Khursudi, Bastul and Asumakunda revealed high yield potential, while N22, Salampikit, Browngora, CR Chan 40, Kalakeri and Saria B were identified to have high degree of drought tolerance. High tillering capacity (Harisankar, CR Dhan 143-2-2, Kinari, Hiran, Badi and Kutiarasi), panicle (Sarian, Dhobasaria, and Anjali) and more number of grains per panicle (Padarabank, Pustak and Pankopoat) were recorded in few land races. Chinger -2 had very bold grains and popular upland varieties e.g., Khandagiri, Vanaprabha and Mandakini revealed higher grain and kernel length. Estimates of regression co-efficient for panicle weight (PW) and kernel breadth (KB) were found significant at 1% level of significance indicating that these two component traits would have definitely predominant influence on seed yield in upland rice.

Keywords Selection strategy, Local upland rice, Drought resistance, Germplasm conservation.

Introduction

Genetic improvement of rice in India and many other rice growing countries has already achieved yield plateau for medium land irrigated rice ecosystems, but areas pertaining to rainfed rice ecosystems particularly upland situation are constrained with low productivity owing to ecological adversities. Globally, about 100 million people niw depend on upland rice as their daily staple food. Almost two-third of the upland rice area is in Asia and in particular Bangladesh, Cambodia, China, India, Indonesia, Myanmar, Thiland and Vietnam have major area under upland rice. In India, 62% of total area under rice

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Table 1. Estimates of variability for seed yield and its component traits.

Parameters	DF	DM	LRS	DRS	LSD	LA	CI	ZTS	BLB	PHT	EBT	PL	PW
Mean	69.3	99.2	5.1	4.8	4.4	40.9	9.4	2.1	4.2	114.5	314.81	22.1	1.5
Range	48.9-106.9	78.3-135.3	0.5-9.3	0.6-9.4	0.8-8.6	18.0-75.0	1.3-15.7	0.6-8.6	0.8-9.3	88.1-138.1	180.4-461.9	15.0-28.0	0.5-3.7
Ph. variance	104.1	100.9	5.6	6.7	3.6	153.1	6.2	3.4	2.6	207.7	5934.8	8.1	0.5
CV(%)	14.7	10.1	46.8	53.6	42.8	30.2	26.5	86.5	38.5	12.5	24.4	12.8	49.6
CD 5%	6.6	4.5	1.8	1.6	1.5	1.2	0.3	1.4	1.4	3.2	10.3	1.2	0.2

Table 1. Continued

	G/P	GW	GL	GB	GL/GB	KL	KB	KL/KB	F%	SV
Mean	65.1	20.7	8.1	2.0	4.1	5.7	1.7	3.2	70.7	28.5
Range	31.6-149.3	11.5-29.4	5.9-9.5	1.3-2.9	2.5-5.9	4.1-7.4	1.0-2.1	2.2-5.2	20.3-95.9	14.7-36.6
Ph. variance	722.4	17.7	0.6	0.06	0.33	0.36	0.05	0.27	265.9	36.9
CV (%)	41.3	20.3	9.4	11.8	14.0	10.4	12.2	15.9	23.0	21.2
CD 5%	5.9	0.9	0.2	0.1	0.4	0.06	0.09	0.2	2.2	1.4

is rain fed [1]. Drought is the predominant cause of yield reduction under rainfed rice production systems. However, the ongoing breeding strategies have not been able to make any break through to develop drought-tolerant cultivars.

The traditional upland rices of Odisha are characterized by early maturity, medium to short height, thin culm, few tillers, small panicles and often red/ light red kernel [2]. The existing genotypes are rarely adaptable to pre and post-monsoon drought situation. Besides, continued human selection and monoculture resulted loss of genes and narrowing of the genetic base in rice [3, 4] resulting increased vulnerability to disease epidemics, pest infestation and abiotic stresses. However, Odisha is the genetic paradise of rice and its Jeypore tract (Koraput is considered as the home for a rich diversity of landraces [5]. These act as heart and soul of rice owing to the wealth of genes they contain. Plant breeders can harness to these valuable genes for genetic improvement in upland rice.

Seed yield is a complex trait and it is determined by mutual relatedness among the component morpho-economic traits. Indiscriminate selection of plants on a massive scale in any crop often results in an immense wastage of time and resources. Success rate will improve with the increase of genetic variability and availability of a selection strategy. Therefore, an attempt has been made to formulate an effective selection strategy based on physiological and morpho-economic features including quality traits in a set of upland land races of rice.

Materials and Methods

A set of 96 short duration local land races collected from different corners of Odisha along with already identified drought tolerant donors from gene bank at CRRI, Cuttack and a few high yielding rice varieties were assessed for genetic variation in terms of 23 agro-economic traits including seed yield and ancillary traits; drought tolerance parameters (leaf rolling, drought recovery, leaf drying), physiological traits (leaf area and chlorophyll index), tolerance to nutritional stress (zinc tolerance) and bacterial leaf blight.

The field experiment comprising above 96 germplasm lines were laid out in augmented design with four blocks and 23 varieties plus four promising standard check varieties (N22, Vandana, Khandagiri and Mandakini) in each block under upland situation. Each genotype was sown in three rows of 3 m length with a spacing of 20 km between rows and 10

Table 2. Frequency distribution of 96 germplasm lines in different class intervals. N.B. :: C.I.–Class interval, F–Frequency of genotypes in the class interval.

LDS		EBT		PW		G/P		GW		GL	
C.I.	f	C.I.	f	C.I.	f	C.I.	f	C.I.	f	C.I.	f
0	0	<200	9	<1	26	<40	20	<12	1	<6.5	5
0-1	2	200-250	14	1.0-1.5	29	40-60	26	12-15	4	6.5-7.0	3
1-3	27	250-300	15	1.5-2.0	16	60-80	29	15-18	23	7.0-7.5	10
3-5	37	300-350	34	2.0-2.5	13	80-100	12	18-21	26	7.5-8.0	14
5-7	20	350-400	11	2.5-3.0	5	100-120	3	21-24	19	8.0-8.5	32
7-9	10	400-450	8	3.0-3.5	4	120-140	3	24-27	16	8.5-9.0	24
9	0	>450	5	>3.5	3	>140	3	>27	7	>9.0	8

Table 2. Continued.

GB		KL		KB		F%		SY	
C.I.	f	C.I.	f	C.I.	f	C.I.	f	C.I.	f
<1.50	3	<4.5	4	<1.0	0	<35	3	<15	2
1.50-175	6	4.5-5.0	3	1.0-1.2	2	35-45	5	15-20	13
1.75-2.00	34	5.0-5.5	19	1.2-1.4	3	45-55	7	20-25	7
2.00-2.25	42	5.5-6.0	40	1.4-1.6	10	55-65	16	25-30	28
2.25-2.50	9	6.0-6.5	22	1.6-1.8	28	65-75	21	30-35	38
2.50-2.75	1	6.5-7.0	5	1.8-2.0	33	75-85	21	>35	8
>2.75	1	>7.0	3	>2.0	20	>85	23	–	–

cm between plants. Normal plant protection measures were taken to check development of diseases and population of insect pests. Other management practices were followed as per recommended package of practices. Similar field experiment comprising the same set of test genotypes was necessitated for proper assessment of drought tolerance (0-9 scale) during summer season.

Observations were recorded on five randomly selected plants from middle row of each plot for all biometric traits except days to maturity and grain yield which were recorded on plot basis and 100-grain weight, which was taken from random sample of seeds of each plot. Data were subjected to routine statistical analysis following Panse and Sukhatme [6]. The partial regression coefficients for yield determining traits were worked out to fit the regression equation as per method of Singh and Choudhury [7].

Results and Discussion

With the alarming strinking of natural resources (land and water) and adverse affects of climate change on agriculture, it becomes extremely difficult task to produce food for seven billion people of the world. Recurrent erratic rainfall and high temperature have drastically reduced the productivity. To meet the food demands of 2050, at least 70% more food will have to be produced at an annual rate of increase of 44 million tons. Therefore, the breeding strategies in rice must be reoriented to achieve high productivity under drought stress. Genetic makeup of the varieties and the relevant production technologies are the major crucial factors to augment productivity in rice. Short duration rice varieties are suitable to combat frequent drought spell spread over seasons. However, the varieties so far developed are not up to the mark in terms of productivity. The ruling upland rice varieties e.g., Khandagiri, Parijar, Udaygiri, Naveen and Nilagiri have practically poor genetic potential for seed yield (<20q/ha) and lack abiotic stress tolerance. In contrast, the available land races still serves as huge reservoir of valuable genes for biotic and abiotic stresses. The genotypes with unique desirable morpho-economic characteristics are likely to produce transgressive segregants in the recombination breeding owing to vast

Table 3. Regression analysis of yield component traits on seed yield. N.B. : Coefficient of partial determination (R^2)=0.7633.

Estimates of regression	a-values	LDS (X1)	EBT (X2)	PW (X3)	G/P (X4)	GW (X5)	GL (X6)	GB (X7)	KL (X8)	KB (X9)	F (X10)
b-value	-12.365	0.420	0.051	2.978**	0.014	0.046	1.773	2.550*	-0.438	2.736**	0.067
SE (b)	4.719	0.184	0.005	0.938	0.025	0.111	0.762	2.531	0.986	2.856	0.025
t-value	–	2.28	10.2	3.17	0.56	0.41	2.32	1.00	0.44	0.95	2.68
Regression equation	Y (Seed yield)= -12.365+0.420X1+0.051X2+2.978X3+0.014X4 + 0.046X5 + 1.773X6 -2.550X7 -0.438X8 + 2736X9 + 0.067X10										

scope of shuffling of genes through genetic recombination. However, the success rate will improve with the increase of genetic variability.

Genetic variability

Variation and selection are the two basic requirements of genetic improvement in any crop. Without variation, selection becomes ineffective. Therefore, knowledge on the extent of genetic variability with regards to various traits and their nature of transmission to the succeeding generations is indispensable for reliable selection. The amount of genetic variability of a species is essential for its survival and adaptation in different environments. Landraces retain higher genetic variability [8] which enable them for better environmental adaptation [9]. The main reasons of such adaptive advantage are the genetic factors involved in changes of allele frequencies acting on each landrace, such as cross pollination and migration, seed mixture, founder effect, genetic drift, or adaptability selection [10, 11].

The present set of upland rice genotypes revealed a wide range of variation for all agro-economic traits including drought tolerance, physiological traits, zinc tolerance and tolerance to BLB. The overall mean value, range, phenotypic variance, co-efficient of variability and critical difference (CD) between adjusted value of a test variety and a check variety mean have been presented in Table 1. The range of each agro-economic trait was tremendously high. The phenotypic variance may not give useful information for comparison among agro-economic traits as it is not unit free. However, co-efficient of variation which is expressed in percentage may be suitably used for comparison and selection of trait(s) with high variability. In the present pursuit, 9.4% in case of grain length to 86.5% in case of zinc tolerance. Among the agro-economic traits, all the three drought tolerance parameters (LRS, DRS and LDS), zinc tolerance, BLB tolerance, panicle weight and grains per panicle had shown high CV (≥40%). Hence, there could be tremendous scope for selection of drought tolerant genotypes with desirable yield contributing traits (panicle weight and grains/panicle) along with zinc tolerance and tolerance to BLB. Gomathinayagam et al. [12] studied the genetic variability in 40 upland rice genotypes which revealed high coefficient of variability for number of effective tillers per plant, grain yield per plant. Rao [13] observed highest genetic variation in grain yield followed by percentage of filled spikelets in very early rice genotypes under upland condition. While, Yadav et al. [14] revealed significant variability for number of tillers per plant, panicle length, number of grains per panicle, 100-seed weight and grain yield per plant in a set of 124 rain fed landraces of rice.

Frequency distribution of test genotypes in different class intervals is presented in Table 2, Only two genotypes e.g., Kinari and Chinger-2 out of 96 test entries showed high degree of drought tolerance based on leaf drying score. Six genotypes (Harisankar, CR Dhan 143-2-2, Kinati, Hiran, Badi and Rutiarasi) for EBT/m^2 and three varieties each for panicle weight (Sarian, Dhobasaria, and Anjali: >3.5 g) and grains per panicle (Padarabank, Pustak and Pankopost : >140) were shown to occur in the extreme boundary in the

Table 4. Promising upland land races of rice in relation to specific stable morphological traits.

Characters	Range	Promising upland rice genotypes
Days to 50% flowering	48.9–106.9	Early flowering: Setka-1, Danisaria, Podasankara, Dangaradhan, Bhogi, Dasaharadhan, Paradhan, Nandigiri, Dhobasaria, Dhalashree-B, Saria-B, Kapaanthi, Zhu 11–26
Days to maturity	78.3–135.3	Early maturity : Setka-1, Danisaria, Podasankara, Dangaradhan, Bhogi, Dasaharadhan, Paradhan, Nandigiri, Dhalashree-B, Saria-B, Zhu 11–26
Leaf rolling	0.5-9.3 (0-9 scale)	Saria-B, CR Dhan 40
Drought recovery	0.6-9.4 (0-9 scale)	Biramani, Saria-B, Browngora, CR Dhan 40, Kalakeri
Leaf drying	0.8-8.6 (0-9 scale)	Kharkoili, Chinger-1, Dengabari, Khursudi, Kinari, Dular, Kusuma, Damaraphuli, Chinger-2, Ambajhuka, Saria-B, Kalakeri, Browngora, Salampikit
Leaf area (cm^2)	18.0–75.0	Sanarasi, Pugakal, Karanga, Ambajhuka, Haladigundi and Padarabank
Chlorophyll inex	1.3–15.7	Kantadumer, Bastul, Litipiti, Dal, Jhulipuagi and Setka-1
Zinc tolerance	0.6–8.6 (0-9 scale)	Kusuma, Sanarasi, Dasaharadhan, Kutiarasi, Karanga, Kenduphula, Ambajhuka, Kunor, Padarabank, Jhitipiti, Ras, Pora
BLB tolerance	0.8-9.3 (0-9 scale)	Salampikit and N 22
Plant height	88.1–138.1	Dwarf plant types: Khandagiri, Setka-2, Dhubasaria, Malkadna, Bhogi, and Jhulipuagi Tall plant types: Ninibudhi, Badi, Harisankar, Pandeydhan, Khursudi, Kinari, jhirkabanji, Merlo, Barei, Pora Intermediate plant types : R est of the genotypes
Ear bearing tillers	180-4–461.9	Khandagiri, Harisankar, Kahnei, Kinari, Merlo, Jhulipuagi, Barei, Kutiarasi, Hiran, CR 143-2-2, Ninibudhi, Badi, Ranh gahazari
Panicle length (cm)	15.0–28.0	Kantadumer, Kharkoili, Sadabahar, Kusuma, Hiran, Lalubadikaberi, Pandeydhan, Dular, Merlo, Rasakadali, Damaraphuli, Biramani, Kalakusuma, Sarian, Haladigundi, Padarabank, Mahulakunchi, Somo, Kanding
Panicle weight (g)	0.5–3.7	Salampikit, Lalubadikaberi, Dular, Pankapota, Sarian, Padarabank, Somo, Asumakunda, Nandigiri, Dhobasaria, Kapaanthi, Pustak, CR Dhan 40, Anjali, Kantadumer
Grains/Panicle	31.6–149.3	Dhobasaria, Anjali, Dular, Pankapota, Sarian, Padarabank, Nandigiri, Asumakunda, Pustak, CR DHAN 40, Lalubadikaberi
1000-Grain weight (g)	11.5–29.4	Kantadumer, Karanga, Kandasuri, Dhobasaria, Kapaanthi, Saria, Kalakeri
Grain length (cm)	5.9–9.5	Lalubadikaberi, Kahnei, Jhulipuagi, Karanga, Dasaharadhan, IR 87707-445-B-B
Grain breadth (cm)	1.3–2.9	Chinger-2, Safri-17, Pustak, Kantadumer
Grain length/breadth	2.5–5.9	Setka-1, Hiran, Rangahazari, Damaraphuli, Sanarasi, Sadabahar, Khandagiri, Sahbhagidhan
Kernel length (cm)	4.1–7.4	Kahnei, Kantadumer, Mandakini, Lalubadikaberi, Karanga, Padarabank, Jhitipiti, Dasaharadhan, IR 87707-445-B-B, Vanaprava, Khandagiri
Kernel length/breadth	2.2–5.2	Setka-1, Mandakini, Ninibudhi, Badi, Rangahazari, Damaraphuli, Khandagiri, Hiran
Fertility (%)	20.3–95.9	Khursudi, Dular, N22, Asumakunda, Pustak, Kandasuri, Kanding, Dhanisaria, Nandigiri, Dhubasaria, Dhalashree-B and CR 143-2-2, Sahbhagidhan
Seed yield (q/ha)	14.7–36.6	Khursudi, Bastul, Asumakunda

frequency distribution. Similarly, a few test genotypes had shown excelling performance for grain weight and quality traits. For instance, a single land race Chinger-2 was shown to have very bold grains (GB>2.75 mm) and three popular upland rice genotypes e.g., Khandagiri, Vanaprabha and Mandakini revealed kernel length even more than 7 mm. Sharma et al. [15] recorded a range of 8.4–25.5 g for 1000-grain weight in a set of 43 traditional upland rice. In the present set of germplasm, twenty three genotypes had recorded >85% grain fertility percentage among which Dhanisaria and Dhobasaria revealed highest fertility status (>95%). In the present investigation, Vandana yielded highest among the check varieties. Hence, Vandana was considered best standard check variety. Significant difference of adjusted mean values of a test genotype from that of Vandana was therefore, considered for varietal comparison. With regard to productivity, eight test genotypes e.g., Pandeydhan, Khursudi, Haladigundi, Asumakunda, Dhobasaria, CR 143-2-2, CE Dhan 40 and Sahbhagidhan were placed in the extreme class interval with grain yield ≥35.0 q/ha. These may serve as valuable material for genetic improvement of upland rice through recombination breeding.

Selection strategy

The knowledge of genetic variability and imposing proper selection strategy is imperative for efficient sampling and utilization of germplasm. Plant breeders always look for combining desirable genes from diverse germplasm into a single genotype. This warrants immediate genotypic characterization followed by pre-breeding to select valuable germplasm lines resulting the development of a core germplasm collection. Morphological characterization of germplasm collections is an important step in this regard. Such a preliminary knowledge would serve for better planning and use of genetic stocks in crop improvement program. The productivity per se is a comples character. Many often direct selection based on per se grain yield led to missing of valuable breeding materials which otherwise have potential genotypic worth for some specific raits. Therefore, it needs proper selection strategy often with the help of suitable statistical method.Regression analysis of yield component traits on seed yield could establish a basis of selection based on important yield contributing characters simultaneously. In the present set of test materials, the partial regression co-efficients for yield determining traits were worked out (Table 3) with a view to fit the regression equation Y (Seed yield)= -12.365+ $0.420X_1 + 0.051X_2 + 2.978X_3 + 0.014X_4 + 0.046X_5 + 1.773X_6 - 2.550X_7 - 0.438X_8 + 2.736X_9 + 0.067X_{10}$; where X_i -represents independent variables e.g., leaf drying score (LDS), number of ear bearing tillers/m^2 (EBT), panicle weight (PW), grains/panicle (G/P), 1000-grain weight (GW), grain length (GL), grain breadth (GB), kernel length (KL), kernel breadth (KB) and grain fertility percentage (F%). As a whole, 76.33% of phenotypic variation was explained by 23 characters under study as revealed from coefficient of determination value (R^2=0.7633). Regression co-efficients of panicle weight (PW) and kernel breadth (KB) were found significant at 1% level of significance indicating that these two component traits have definitely predominant influence on seed yield in upland rice. In contrast, grain breadth had also significant *b*-value but acted negatively (*b*= -2.550*). However, such a comparison of charcters based on estimates of the partial regression co-efficients has no meaning as *b*-values are in fact not unit free. Therefore, overall mean value of each component traits was multiplied with respective *b*-value and expressed in terms of yield units. The relative magnitude of these products may be considered for longistic comparison among component characters towards contribution for seed yield. On verification of the product values, it was revealed that number of ear bearing tillers/m^2 and grain length followed by grain breadth, fertility percentage, kernel breadth and panicle weight have high contribution for expression of seed yield.

In this investigation, a few genetically potential genotypes have been isolated through evaluation of 96 germplasm lines including four standard checks in an augmented design. Adjusted values were derived from observed value of each agro-economic traits following standard statistical procedure. Each character was critically examined against the best standard check and promising genotypes with respect to specific traits have been sorted out and presented in Table 4 for ease of better comprehension. The best entries with regard to specific traits may be utilized as donors in future breeding program.

Among the standard check varieties, Vandana was the highest yielder (34.8 q/ha) and hence could be considered as best standard check variety in terms of productivity. Genotypes exceeding 34.8 q/ha in seed yield could be considered as significantly higher yield as compared to best standard check variety (Vandana). These include Khursudi, Bastul and Asumakunda. Besides, a few genotypes seen to be comparable or recorded marginally increased over Vandana in seed yield were Lalubadikaberi, Pandeydhan, Kinari, Dular, Rasakadali, Sarian, Jhulipuagi, karanga, Kenduphula, Kunor, Haladigundi, Mahulakunchi, Kandasuri, Kanding, Nandigiri, Dhubasaria, Hiran, CR 143-2-2, CR Dhan 40, Sahbhagidhan and Sneha. Vandana attained 50% flowering after 64.0 days and physiological maturity after 91.7 days. Bhogi was identified as the earliest in flowering and maturity duration (48.9* and 78.3*) and as expected it has low yield potential (25 q/ha). However, some of the important early flowering genotypes with moderately high seed yield have been sorted out were Nandigiri, Dhubasaria, Setka-1, Dhanisaria, Saria-B and Zhu 11-26. Khursudi-a local land race was selected as comparatively dwarf plant type among the local land races. Besides, N22, Salampikit, Browngora, CR Dhan 40, Kalakeri and Saria-B to name a few were identified to have high degree of drought tolerance. These germplasm lines could be of emense value for future breeding program for augmentation of productivity *per se*.

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